MANCOS FRACTURED SHALE PLAY

(USGS Designation 2208)

General Characteristics

The Mancos Fractured Shale Play is a confirmed, unconventional, continuous-type play. It is dependent on extensive fracturing in the organic- rich marine Mancos Shale. Most developed fields in the play are associated with anticlinal and monoclinal structures around the eastern, northern, and western margins of the San Juan Basin (Figs. UM-28 and UM-29).

Reservoirs: Reservoirs are comprised of fractured shale and interbedded coarser clastic intervals at approximately the Tocito Lentil stratigraphic level.

Source rocks: The Mancos Shale contains 1-3 weight percent organic carbon and produces a sweet, low-sulfur, paraffin-base oil that ranges from 33° to 43° API gravity.

Timing: The Upper Mancos Shale of the central part of the San Juan Basin entered the thermal zone of oil generation in the late Eocene and of gas generation in the Oligocene.

Traps: Combination traps predominate. Traps are formed by fracturing of shale and by interbedded coarser clastics on structures.

Exploration status and resource potential: Most of the larger discoveries, such as Verde and Puerto Chiquito, were made prior to 1970, but directional drilling along the flanks of some of the poorly explored structures could result in renewed interest in this play.

Characteristics of Mancos Fractured Shale Play in the Ute Mountain Ute Indian Reservation

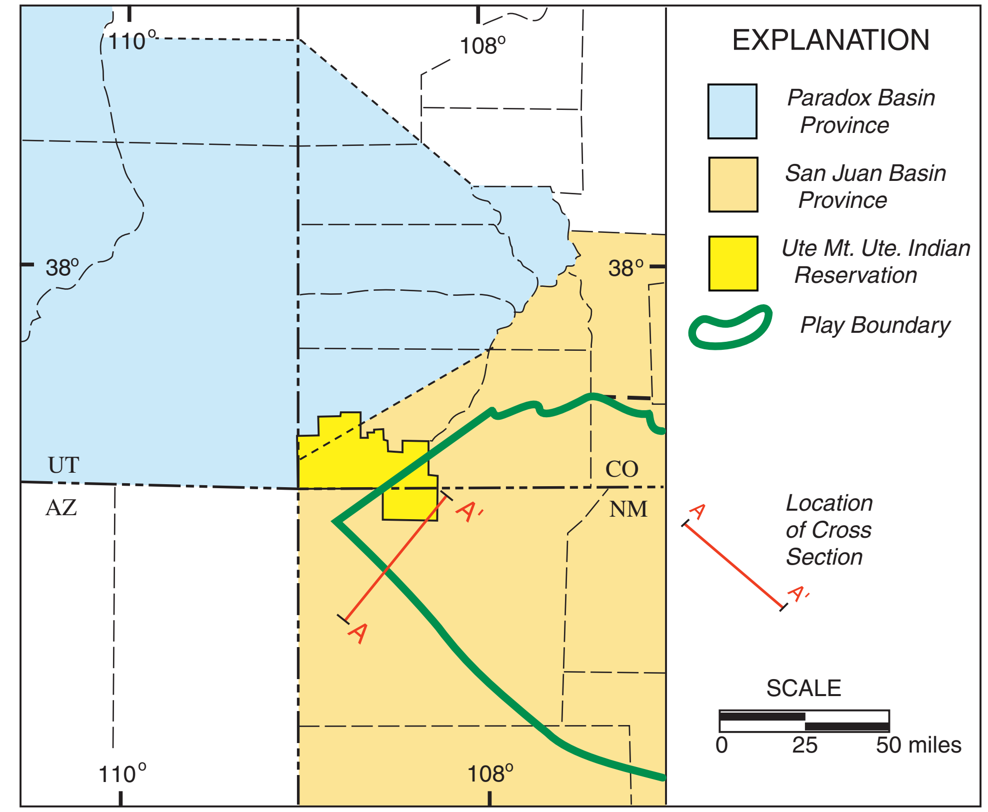
The Mancos Fractured Shale Play produces oil from fractures in the Niobrara-Carlile age clastic sediments (Fig. UM-30) which represent the first regressive wedge in the San Juan Basin. These sediments have little or no effective porosity and permeability except that associated with fractures. The units of interest to oil exploration are the basal Niobrara (lower Tocito Sandstone), Niobrara-Carlile unconformity (upper Carlile Shale-Tocito Sandstone contact), and Carlile Shale/siltstone contact interval above the Juana Lopez. The Niobrara-Carlile stage is laterally consistent with respect to siltstone content, cement content, and other observable stratigraphic phenomenon.

The Hogback Monocline and Mancos Creek Monocline (Fig. UM-29) are the structural features associated with fractures in the Mancos Shale. The Hogback Monocline is located in the northwest flank of the San Juan Basin in the southeast section of the Ute Mountain Ute Indian Reservation. It has a dip as great as 60° and has up to 8000 feet of structural relief. The Mancos Creek Monocline is located south of the reservation and extends only a few miles. Fractures are mostly associated with areas of maximum flexure and where anticlines and synclines intersect the monoclines (Figs. UM-31 and 32). The fractures are best developed parallel to the trend of the fold. They range in size from hairline cracks to 1 ¾ inches wide.

Oil reservoirs associated with the Mancos Fractured Shale Play depend on porosity and permeability provided by the fractures. The reservoirs are lithologically controlled only to the extent that brittle competent interbeds capable of fracturing are present. The fractures have greater lateral than vertical continuity. The basic tools used in exploration for fracture permeability are structure contour maps and lithofacies maps showing brittle interbeds in dominantly shaly sequences.

Trap types are structural/stratigraphic-fracture traps. The reservoirs are primarily driven by gravity drainage.

Figure UM-28. Location of Mancos Fractured Shale Play (modified after Peterson, 1996) Cross section A-A' is shown in Figure UM-30.



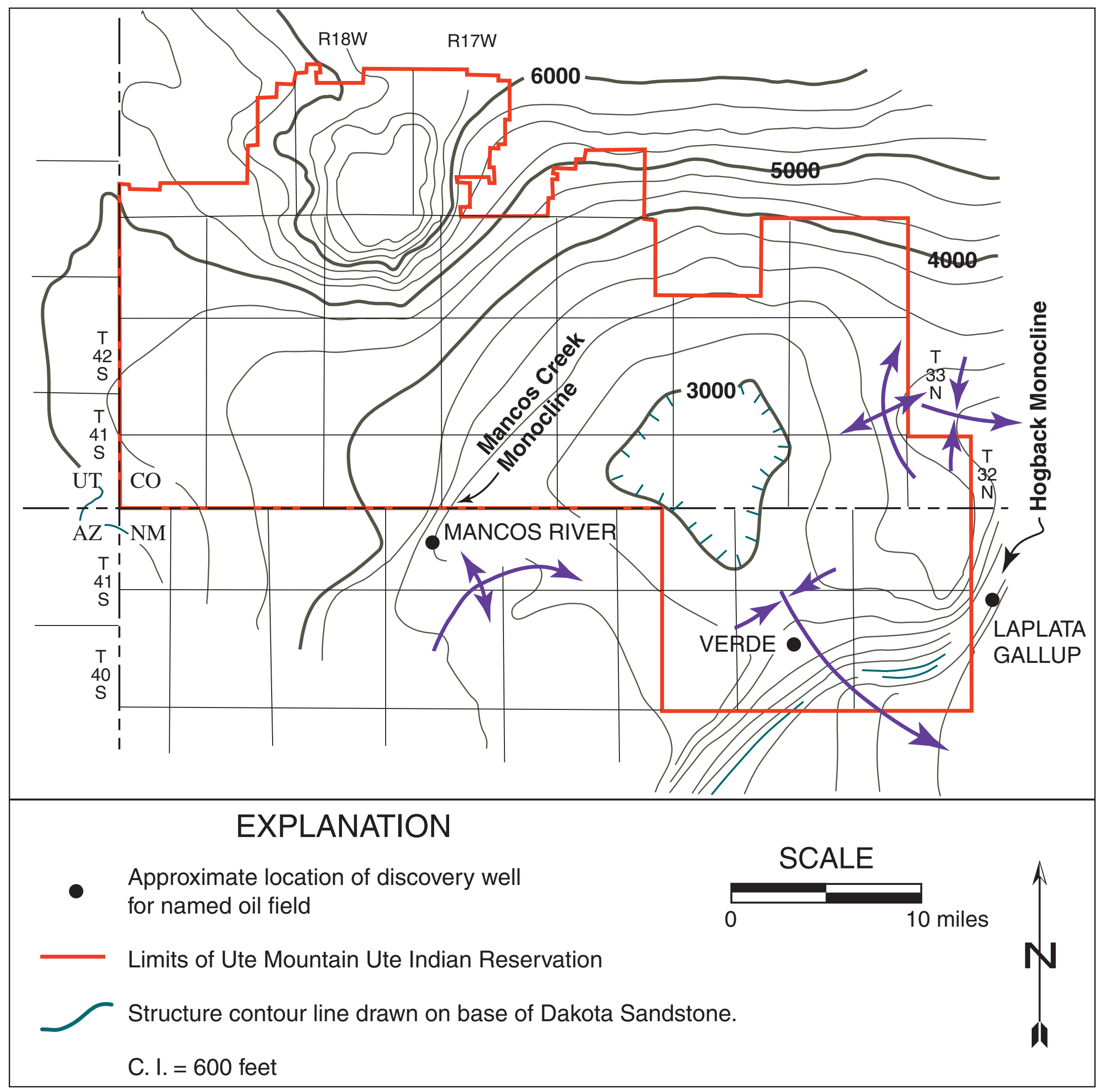


Figure UM-29. Structure contour map of the basal Dakota Sandstone showing the Hogback Monocline, associated folds, and location of oil field discovery wells for fields producing from the Mancos Fractured Shale Play (modified after Anderson, 1995).

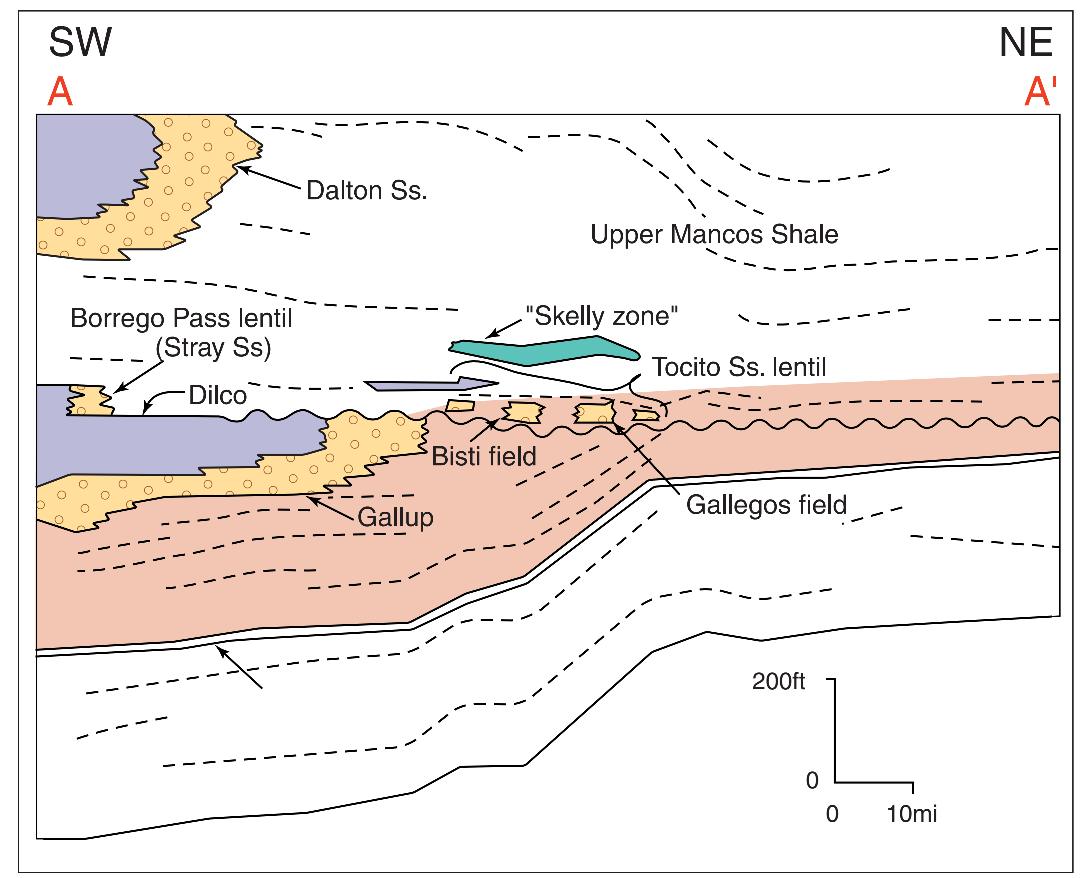


Figure UM-30. Subsurface stratigraphic cross section across the central San Juan Basin. Dashed lines are time marker bentonites or calcareous silty zones (modified from Molenaar, 1973; Tillman, 1985).

Analog Fields inside or near Reservation

(*) denotes field lies within the reservation boundaries

***Verde Oil Field** (Fig. UM-31)

Location of discovery well: se ¼,sec. 14, T31 N, R15W, NMPM (September 1955)
Producing formation: Fractured interval in Niobrara age Mancos Shale
Number of producing wells: 27 (1978)
Production: 7,789,304 bbl. (1977)
Oil characteristics: 38° - 42° API Gravity
Type of drive: Gravity drainage in entire field as a "unit"

La Plata Gallup Field (Fig. UM-32)

Location of discovery well: se ¼, sw ¼, sec 5, T31N, R13W, NMPM (April 1959)
Producing formation: Fractured Mancos Shale.
Number of producing wells: 4 (1978)
Production: 527,882 bbl. (1977)
Oil characteristics: Sweet yellow-green, 30° API Gravity.
Type of drive: Combination gravity and solution gas

Mancos River Field

Location of discovery well: E ½ Sec 15, T32N, R18W, NMPM
Producing formation: Fractured Mancos Shale.
Number of producing wells: 2 (1978)
Production: 22,750 bbl. (1982)
Oil characteristics: 40° API Gravity

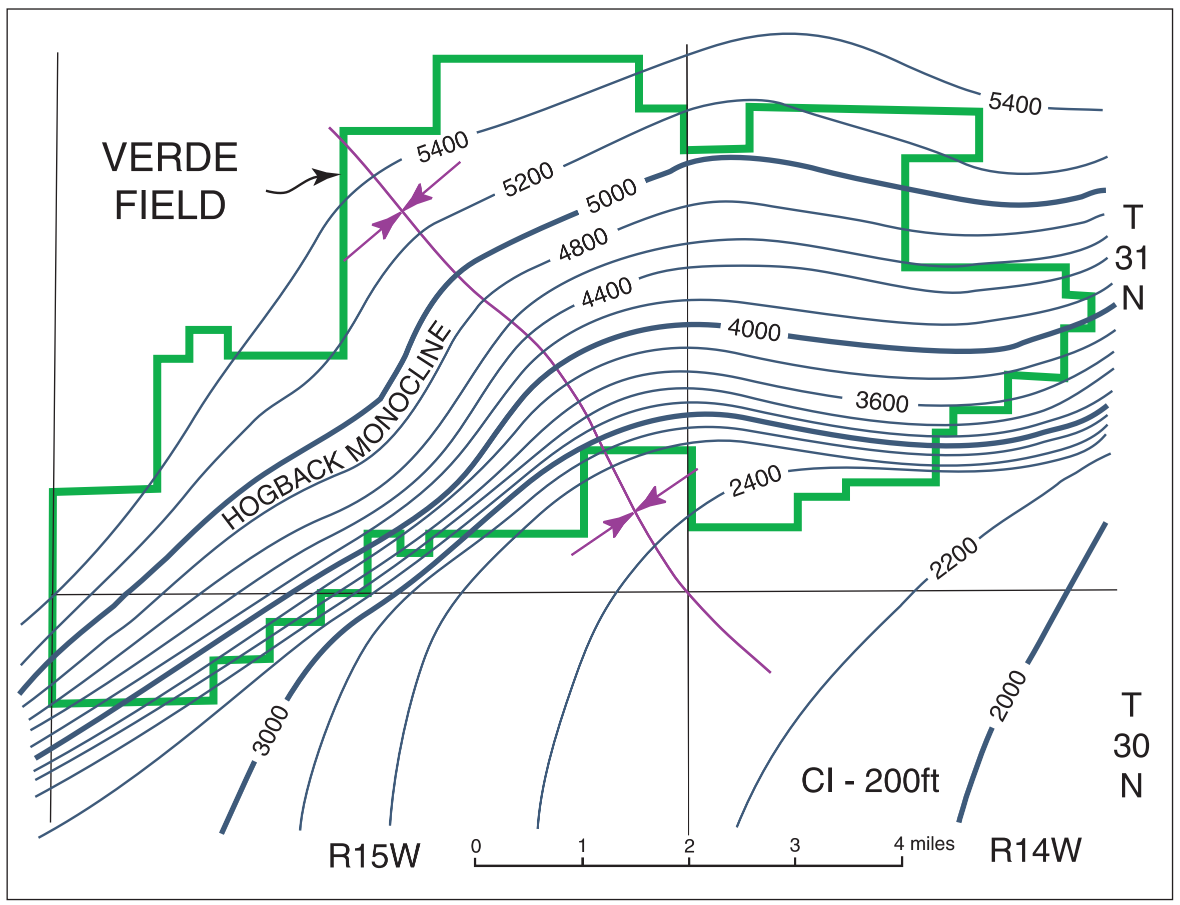


Figure UM-31. Generalized structure contour map of Verde field. Structure contours are on top of the Point Lookout Sandstone Member of the Mesaverde Group (modified from Hayes and Zapp, 1955).

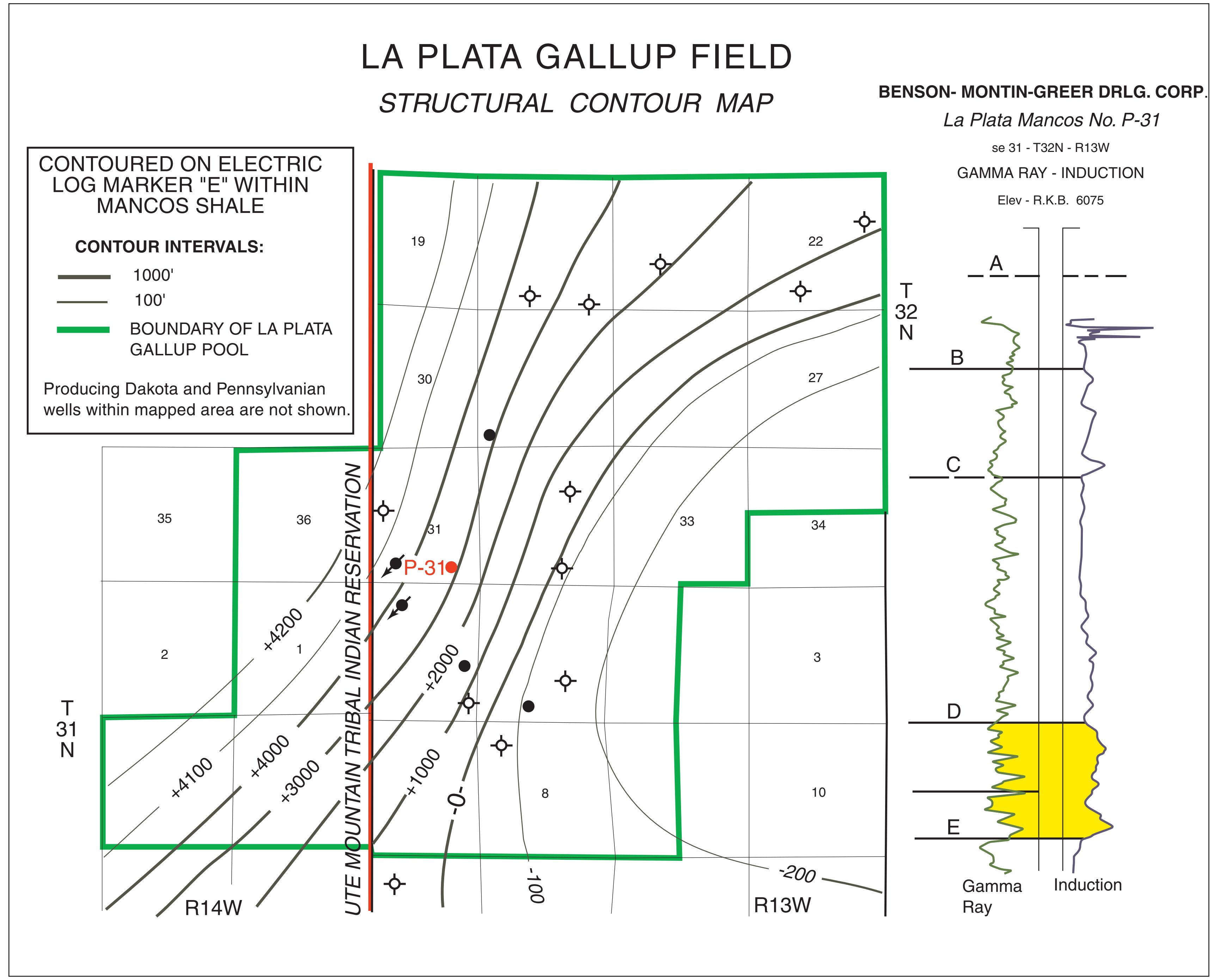


Figure UM-32. Structure contour map and type log of the La Plata Gallup field. Structure contour lines are on the "E" marker within the Mancos Shale (top of the Niobrara Stage) which generally produces the highest electrical log resistivities in the Mancos Shale (modified after Greer, 1978).

Central Basin Mesaverde Gas Play

(USGS Designation 2209)

General Characteristics

The unconventional continuous-type Central Basin Mesaverde Gas Play is in sandstone buildups associated with stratigraphic rises in the Upper Cretaceous Point Lookout and Cliff House Sandstones in the central San Juan Basin (Fig. UM-33). The major gas-producing interval in the San Juan Basin, the Upper Cretaceous Mesaverde Group, is composed of the regressive marine Point Lookout Sandstone, the nonmarine Menefee Formation, and the transgressive marine Cliff House Sandstone. Total thickness of the interval ranges from about 500 to 2,500 feet, of which 20-50 percent is sandstone. The Mesaverde interval is enclosed by marine shale: the Mancos Shale is beneath the interval and the Lewis Shale above (Fig. UM-34).

Reservoirs: Principal gas reservoirs productive in the Mesaverde interval are the Point Lookout and Cliff House marine sandstones. Smaller amounts of dry, nonassociated gas are produced from thin, lenticular channel sandstone reservoirs and thin coal beds of the Menefee. Much of this play is designated as tight, and reservoir quality depends mostly on the degree of fracturing. Together, the Blanco Mesaverde and Ignacio Blanco fields account for almost half of the total nonassociated gas and condensate production from the San Juan Basin. Within these two fields porosity averages about 10 percent and permeability less than 2 mD; total pay thickness is 20-200 feet. Smaller Mesaverde fields have porosities ranging from 14 to 28 percent and permeabilities from 2 to 400 mD, with 6-25 feet of pay thickness.

Source Rocks: The carbon composition (C_1/C_{1-5}) of 0.99-0.79 and isotopic carbon ($d^{13}C_1$) range of -33.4 to -46.7 per mil of the nonassociated gas suggest a mixture of source rocks including coal and carbonaceous shale in the Menefee Formation (Rice, 1983).

Timing and Migration: In the central part of the basin, the Mancos Shale entered the thermal zone of oil generation in the Eocene and of gas generation in the Oligocene. The Menefee Formation also entered the gas generation zone in the Oligocene. Because basin configuration was similar to that of today, updip migration would have been toward the south. Migration was impeded by hydrodynamic pressures directed toward the central basin, as well as by the deposition of authigenic swelling clays due to de-watering of Menefee coals.

Traps: Trapping mechanisms for the largest fields in the central part of the San Juan Basin are not well understood. In both the Blanco Mesaverde and Ignacio Blanco fields, hydrodynamic forces are believed to contain gas in structurally lower parts of the basin, but other factors such as cementation and swelling clays may also play a role. Production depths are most commonly from 4,000 to 5,300 feet. Updip pinchouts of marine sandstone into finer grained paludal or marine sediments account for almost all of the stratigraphic traps with a shale or coal seal.

Exploration Status and Resource Potential: The Blanco Mesaverde field discovery well was completed in 1927, and the Ignacio Blanco Mesaverde field discovery well was completed in 1952. Areally, these two closely adjacent fields cover more than 1,000,000 acres, encompass much of the central part of the San Juan Basin, and have produced almost 7,000 BCFG and more than 30 MMB of condensate, approximately half of their estimated total recovery. Most of the recent gas discoveries range in areal size from 2,000 to 10,000 acres and have estimated total recoveries of 10 to 35 BCFG.

Basin Margin Mesaverde Oil Play

(USGS Designation 2210)

General Characteristics

The Basin Margin Mesaverde Oil Play is a confirmed oil play around the margins of the central San Juan Basin (Fig. UM-35). Except for the Red Mesa field on the Four Corners Platform, field sizes are very small. The play depends on intertonguing of porous marine sandstone at the base of the Upper Cretaceous Point Lookout Sandstone with the organic-rich Upper Mancos Shale.

Reservoirs: Porous and permeable marine sandstone beds of the basal Point Lookout Sandstone provide the principal reservoirs. The thickness of this interval and of the beds themselves may be controlled to some extent by underlying structures oriented in a northwesterly direction.

Source Rocks: The Upper Mancos Shale intertongues with the basal Point Lookout Sandstone and has been positively correlated with oil produced from this interval (Ross, 1980). API gravity of Mesaverde oil ranges from 37° to 50°.

Timing: Around the margin of the San Juan Basin the Upper Mancos Shale entered the thermal zone of oil generation during the Oligocene.

Traps: Structural or combination traps account for most of the oil production from the Mesaverde. Seals are typically provided by marine shale, but paludal sediments or even coal of the Menefee Formation may also act as the seal.

Exploration Status and Resource Potential: The first oil-producing area in the state of New Mexico, the Seven Lakes Field, was discovered by accident in 1911 when a well being drilled for water produced oil from the Menefee Formation at a depth of approximately 350 feet. The only significant Mesaverde oil field, Red Mesa, was discovered in 1924.

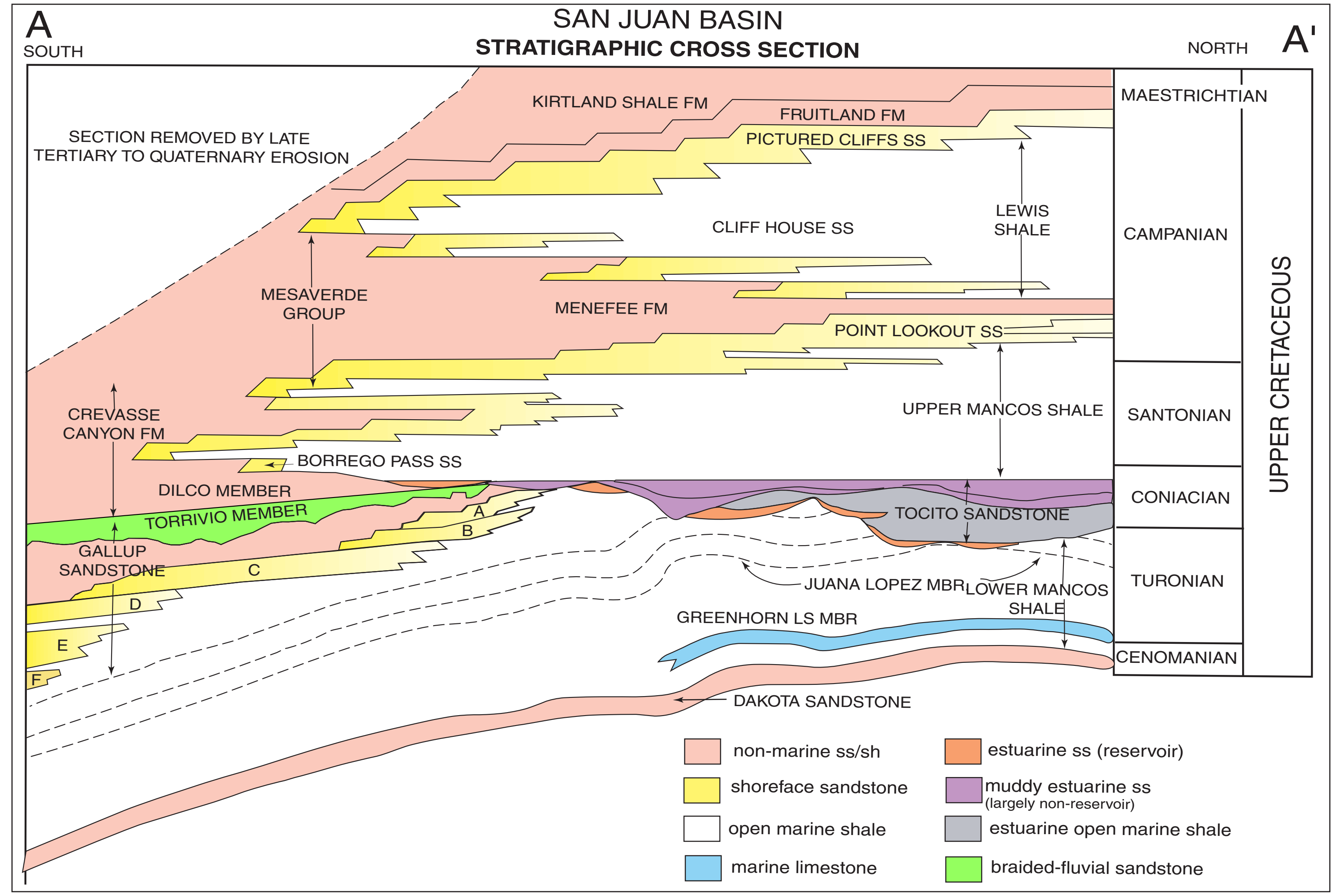


Figure UM-34. Schematic south to north cross section of the Cretaceous stratigraphy in the northern San Juan Basin (modified after Molenaar, 1973, 1983a,b).

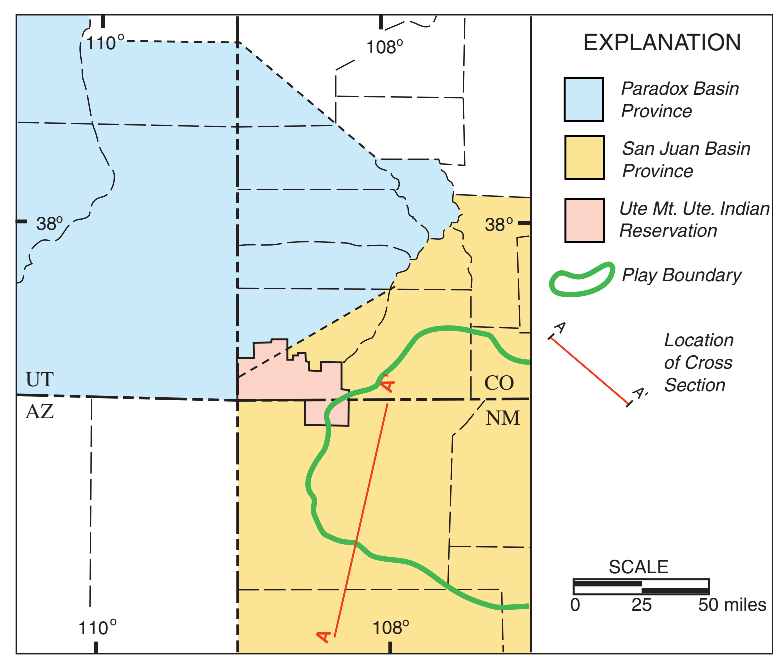


Figure UM-33. Location of the Central Basin Mesaverde Gas Play (modified after Gautier, et al., 1996).

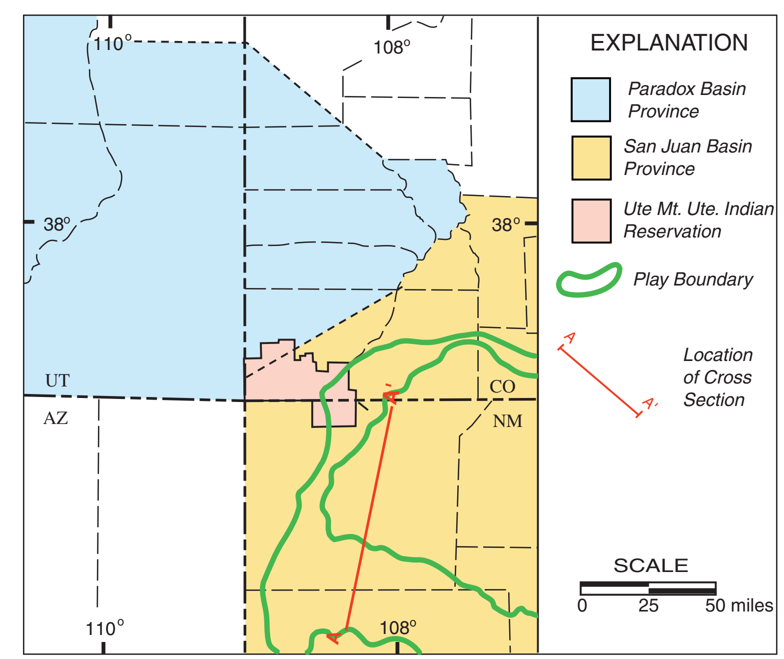


Figure UM-35. Location of the Basin Margin Mesaverde Oil Play (modified after Gautier, et al., 1996).

Basin Margin Mesaverde Oil Play and Central Basin Mesaverde Gas Play

Stratigraphy and Analog Fields

The Cliff House and Point Lookout Sandstones are the producers of the Basin Margin and Central Basin Mesaverde Plays in the Ute Mountain Ute Indian Reservation.

The Point Lookout Sandstone is the most extensive regressive marine Cretaceous sandstone in the San Juan Basin. The unit progrades from southwest to northeast in a series of imbricated sandstone units (Fig. UM-36). The depositional environments present in the Cliff House Sandstone are fluvial/estuarine, shoreface, and delta front. Reservoir characteristic studies have shown that the upper shoreface and shoreface/delta front have the highest permeabilities at 10-80 mD. Permeabilities between 0.3 and 3 mD are more common to lower shoreface sediments. The highest amounts of carbonate cement are present in the lower to middle shoreface. Varying depositional environments and their changing lithologies create distinctive divisions in the Point Lookout log responses (Figs. UM-37, -38, and -39). These divisions are used by exploration geologists to correlate productive zones.

Further work in the Mesaverde reveals the Point Lookout shoreface prograded in a staircase fashion across the basin, as a series of steps and risers until it reached its seaward depositional limit (Fig. UM-36). At this limit, there is a change in the stacking pattern of genetic sequences from seaward stepping to landward stepping. This marks the beginning of the Cliff House shoreface aggradation. Reservoir-quality sandstones in the two vertically stacked shorefaces at the turnaround position are 70 meters thick.

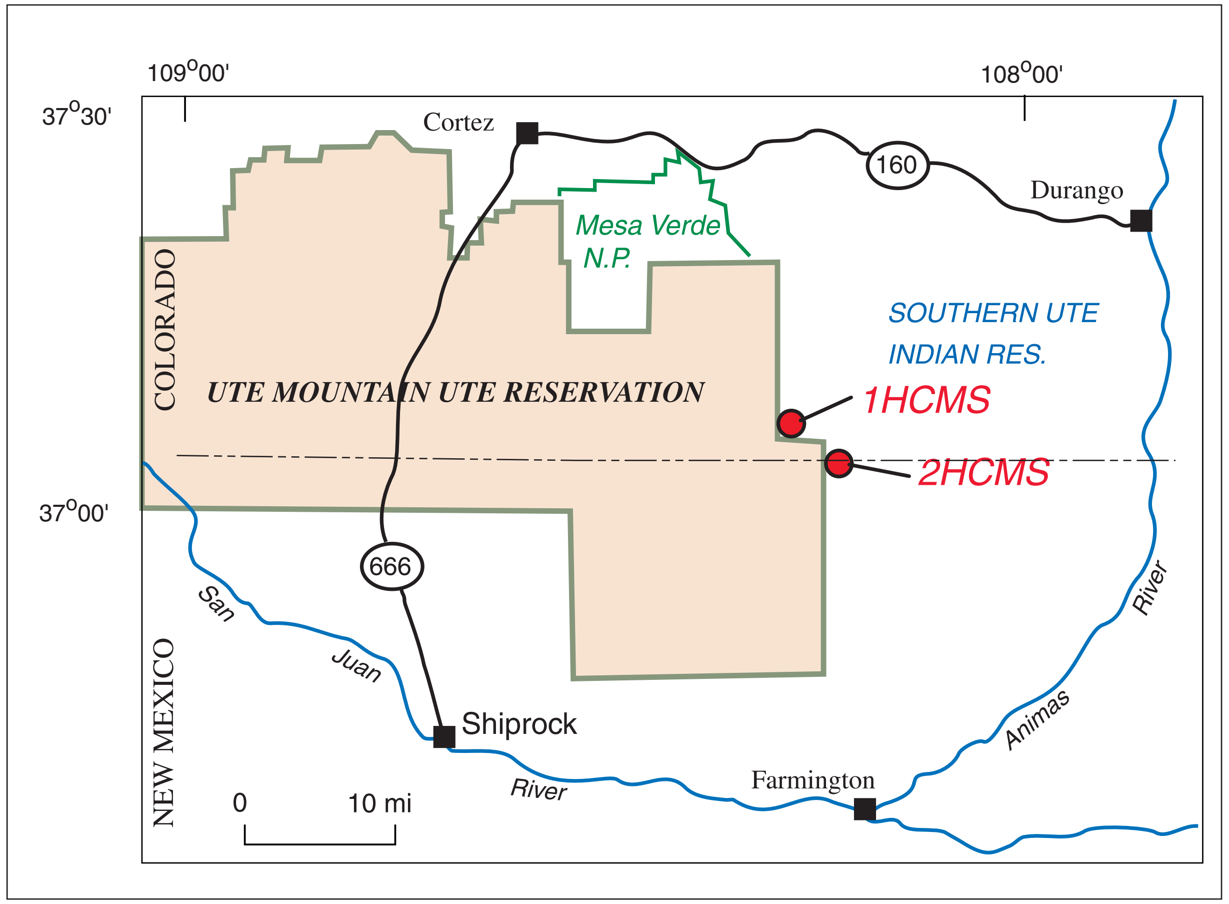


Figure UM-37. Index map showing location of drill holes 1HCMS and 2 HCMS referred to in Figure UM-38 (modified after Keighin, Zech, and Dunbar, 1993).

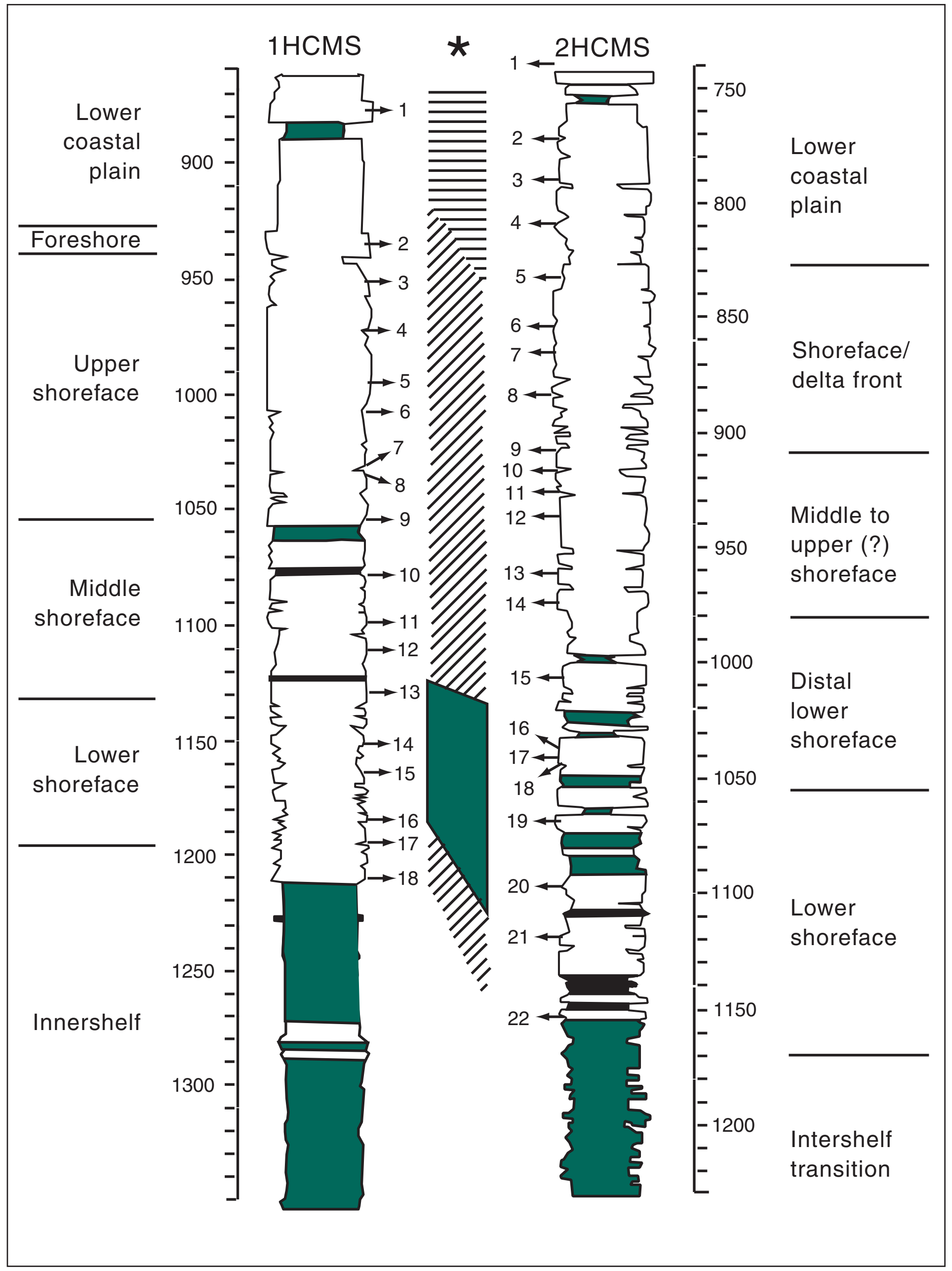


Figure UM-38. Comparison of depositional facies in the Point Lookout Sandstone, as determined from cores, for core holes 1HCMS and 2HCMS (Fig. UM-37). Numbered arrows indicate locations of thin sections examined. (*) patterns indicate zones of mineralogical similarity within depositional environments, as determined by modal point-count analysis (modified after Keighin, Zech, and Dunbar, 1993).

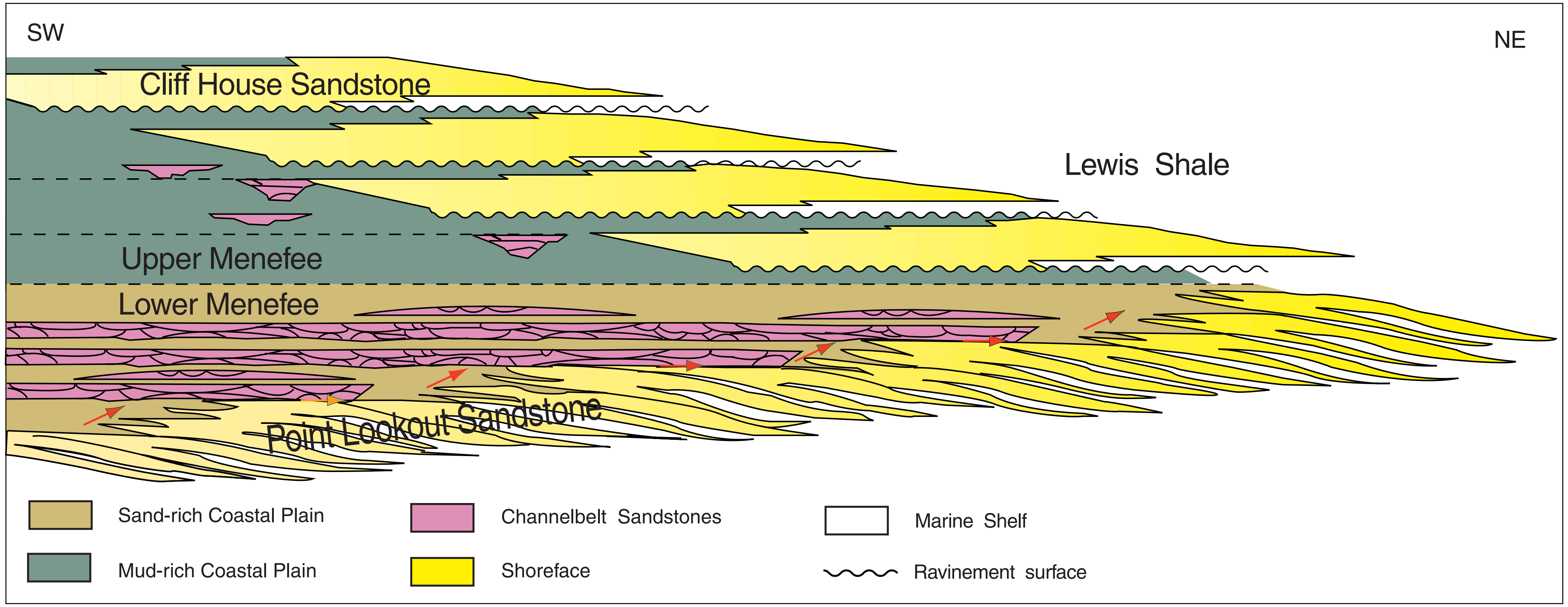


Figure UM-36. Diagram of the stacking patterns of genetic sequences in the Mesaverde Group, and the temporal reflections among the five formations which compose it (modified after Cross and Lessenger, 1997).

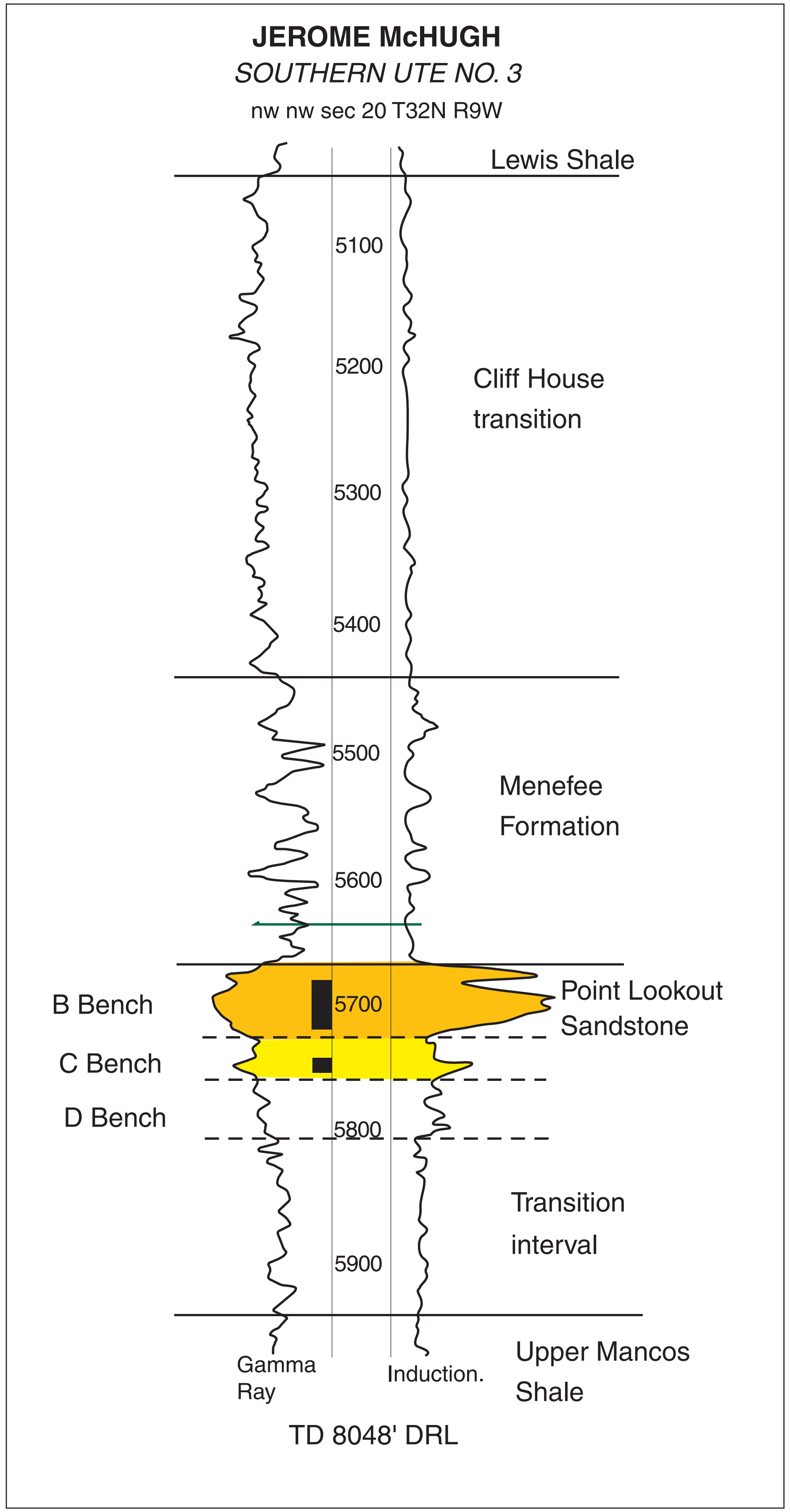


Figure UM-39. Log of the Mesaverde pool stratigraphic units. Well is in the Jerome McHugh Southern Ute NO. 3, NW, NW sec.20, T32N, R9W, La Plata County, CO (modified after Harr, 1988, p. 123).

Analog Fields within or near Reservation

(Oil producing fields belong to Basin Margin Mesaverde Oil Play;
Gas producing fields belong to Central Basin Mesaverde Gas Play)

Nenahnezad Mesaverde

(Fig. UM-40)

Location of discovery well:	nw sw, sec. 10, T29N, R15W (1970)
Producing formation:	Cretaceous, Menefee Formation (lower part)
Number of producing wells:	0
Production:	1025 bbl (1983)
Type of drive:	pumped
Average net pay:	30 feet
Porosity:	23%

Twin Mounds Mesaverde

Location of discovery well:	se sw sec. 4, T29N, R14W (1954)
Producing formation:	Cretaceous Point Lookout Sandstone
Number of producing wells:	0
Production:	654,884 MCFG (1983)
Gas characteristics:	Btu 1,153
Type of drive:	Volumetric with possibly partially active water drive
Average net pay:	10 feet
Porosity:	25%
Permeability:	6 mD

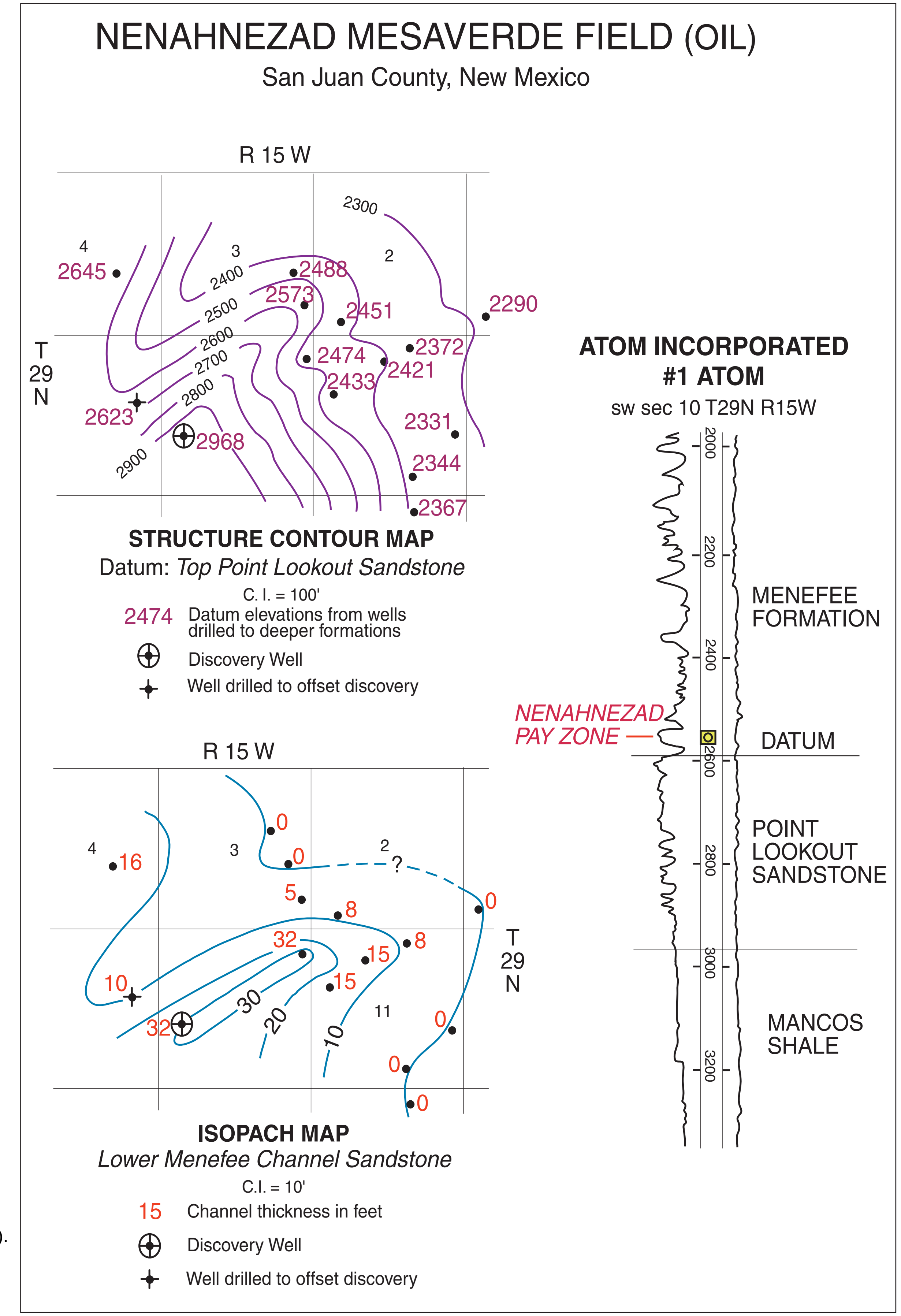


Figure UM-40. Structure contour map, isopach map, and type log for the Nenhnezad Mesaverde field (modified after Meibos, 1983).